Rippled Waters Engineering, LLC

14 September 2020

<u>VIA EMAIL</u>
Mr. Richard Schilling
Township Manager
Bedminster Township
432 Elephant Road
Perkasie, PA 18944

Re: Technical Comments related to the Stormwater Management Ordinance for Bedminster Township Bucks County, Pennsylvania

Dear Mr. Schilling,

This letter serves as an expert opinion and comments on the Stormwater Management Ordinance prepared by Bedminster Township. This report is being provided on behalf of the Lower Delaware Wild & Scenic River Management Council.

For this report, I reviewed the draft Bedminster Township Stormwater Management Ordinance dated June 16, 2020. The context of the comments included herein also refer to the Pennsylvania Municipalities Planning Code and the "Storm Water Management Act" as amended.

This report serves as a summation of comments and concerns related to the draft Stormwater Management Ordinance.

Section 105. Applicability

1. Under Part B, the temporary and permanent management facilities are not defined. It is recommended that this definition be added to Section 202.
2. Under Part D2, prohibited or polluted discharges are not defined. It is recommended that this definition be added to Section 202.
3. The ordinance includes "Alteration of the natural hydrologic regime" under Part D3. Without a definition, this is unclear. Any activity involving grading regardless of size has the potential to alter the natural hydrologic regime. This terminology should be more clearly defined.

Rippled Waters Engineering, LLC
420 Woolf Road, Milford, NJ 08848
732.735.3440
mary@rippledwatersllc.com
www.rippledwatersllc.com

Section 106. Exemptions

1. Part B of the ordinance notes that projects included in Tables 106.1, 106.2, and 106.3 are exempt from peak rate control requirements, however, no mention of exemption from water quality or infiltration requirements is referenced. It is unclear if there are exemptions or not. This should be clarified.
2. Table 106.1 includes threshold values for maximum impervious surface area based on the total parcel size in acres. It is my opinion that a better metric to determine impervious surface area thresholds is by Hydrologic Soil Groups and Land Cover considerations. Hydrologic Soil Groups classify soils based on potential infiltration capability and soils classified as Hydrologic Soil Group A have the highest rate of infiltration, whereas soils with Hydrologic Soil Group D are least permeable and therefore impervious surfaces should be concentrated on these soil types. The definition for HSGs is included in the ordinance and could be used as a basis for defining thresholds for maximum impervious areas for various parcel sizes.
3. Part C2 states that "in lieu of meeting the minimum distance criteria set forth in Table 106.2 above, an applicant may provide documentation from a Professional Engineer registered in the Commonwealth of Pennsylvania that the increased flows from the site leave the site in the same manner as the pre-development condition, and that there will be no adverse effects to properties along the path flow(s)." This exemption criteria gives engineers the ability to complete calculations in any way they deem suitable to provide this justification. A reference to the means and methods expected of the Professional Engineer should be included. For example, a hydrograph for existing conditions should match the proposed hydrograph for all regulated storm events at all time intervals or something to that effect.
4. The restoration requirements under Part C4b, state "the area where existing impervious surface is removed pursuant to Subsection 4.a. above must be restored with a minimum of eight (8) inches of topsoil and stabilized groundcover." To truly restore an area that was impervious, the ground should be decompacted. The decompaction methodology should follow the process detailed under BMP 6.7.3: Soil Amendment & Restoration in the "Pennsylvania Stormwater Best Management Practices Manual" dated December 30, 2006. A copy of this is attached to this comment letter for reference as Attachment B.

Section 107. Waivers

1. Part B of this section indicates that "waivers or modifications of the requirements of this Ordinance may be approved by the Township Board of Supervisors if enforcement will exact undue hardship because of peculiar conditions pertaining to the land in question." More clarity must be provided regarding what conditions constitute "peculiar conditions."

The modifications noted regarding alternative approaches or standards that would provide equal or better compliance seem reasonable and this reference should include waivers in addition to the modifications referenced.

Section 202. Definitions

1. The definition for bankfull is inconsistent with standard definitions for bankfull flow. Consider amending the definition based on Attachment C of this report which was prepared by Penn State University.
2. The definition of stream or watercourse includes all types of streams and appears to be focused on natural stream channels. This definition is appropriate for natural streams; however, the use of the word watercourse appears to be utilized in the ordinance for more man-made features including ditches. It is recommended that the definitions be separated for man-made and natural streams and that the term watercourse be defined independently to avoid confusion.
3. The definition of water quality requirements references 25 Pa Code Chapters 93 and 96 but is not explicit in identifying what requirements there are for water quality. It would be a good idea to refer to the Pollution Reduction Plan in Section 303 or in this definition for additional clarification.

Section 301. General Requirements

1. Part K of this section states that "where a subdivision or land development site is traversed by watercourses, drainage easements shall be provided… The easement shall also require periodic maintenance of the easement area by the landowner to ensure proper runoff conveyance." This is the first instance where the use of the term watercourse is confusing. Streams that are regulated features should not be maintained as referenced by this part. I believe Part K is referring to man-made drainage channels like swales and ditches and should be clarified as such.
2. Under Part L of this section, it states "work within stream shall be subject to approval by the Township and DEP through the Joint Permit Application process." This reference is confusing, but it is assumed that this refers to connecting a man-made channel to a regulated natural stream. This should be clarified.

Section 302. Stormwater Management Districts – Peak Rate Control

1. Part H1 under this section includes a statement that "natural or man-made channels or swales must be able to convey the increased runoff associated with a 2-year return period event within their banks." This is not necessarily consistent with the characteristics for natural streams. Bank forming flows in this region tend to be the 1.5- to 2-year storm event but forcing a certain volume to fit in a "natural stream" is counter to the current focus on stream restoration. Establishing the bankfull characteristics of a

stream should drive the volumes and flows that should be conveyed by natural stream channels. Otherwise, this section of the ordinance has the potential to increase stream erosion and sediment loads in the downstream receiving watercourses.

2. Part H2 of this section states that "natural or man-made channels or swales must be able to convey the increased 25-year return period runoff without creating any hazard to persons or property, or wildlife and aquatic habitat." It is not possible to have a natural channel convey runoff from this large of a recurrence interval. As noted in the comment above, channels should be out of bank for events this large. By forcing runoff in a natural channel for events this large, wildlife and aquatic habitat will be not be protected and the potential for stream erosion and elevated sediment loads traveling downstream will increase.

Section 306. Additional Requirements Applicable to Infiltration Oriented Stormwater Management Systems

1. Part J states that "extreme caution should be exercised where infiltration is proposed in source water protection areas." The ordinance does not define source water protection areas and no mapping is included. To ensure that these areas are protected, these should be referenced in the ordinance.

Section 307. Stream Bank Erosion Requirements

1. In general, this section needs to be clarified as the connection to stream bank erosion protection is unclear. I think it would improve the ordinance and the understanding of what is required if portions of the Pollution Reduction Plan are included in the ordinance or if the PRP is referenced in this section.
2. To ensure that the impaired watercourses in the Township are further protected, additional requirements should be included on protecting stream banks from erosion in the Township. It is my recommendation that sites that include regulated streams should be evaluated by a fluvial geomorphologist or qualified stream restoration professional for erosion and erosion potential at a minimum.
3. Part A of this section states that "a BMP must be designed to detain the proposed conditions 2-year, 24-hour design storm to the existing conditions 1-year flow using the SCS Type II distribution." This wording is a bit unclear. Does this mean that the peak rate of the 2-year proposed conditions storm must match the existing 1-year peak rate? If that is the case, it is unclear how this reduces stream bank erosion. The volume of runoff and the peak rate of runoff drive potential stream bank erosion. This part should be clarified.
4. Part B of this section refers to release of water from a stormwater facility. What does this have to do with stream bank erosion? Clarity on the connection to stream bank erosion should be provided.

5. Under Part C of this section, it states "it is the responsibility of the developer to restore existing eroded stream/channel banks." What is the definition of restore in this context? Additional information should be included in the ordinance to ensure that stream restoration is completed in a way that is beneficial to the streams and provides the required outcome of a reduction in sedimentation and nutrient loading to the impaired watercourses in the Township. It is recommended that restoration be further defined, and that restoration be undertaken only after consulting with the Township professionals, PADEP, and the USACOE.

Section 308. Design Criteria for Stormwater Management Facilities and Best Management Practices

1. Part C8 under this section states that "stormwater collection systems shall be designed to produce a minimum velocity of 3 feet per section when flowing full. The maximum permissible velocity shall be 15 feet per second." It is assumed that this section refers to pipes and does not apply to swales or manmade channels. Velocities of this magnitude are highly erosive in natural stream channels and would require significant armoring and engineered techniques. This seems to be counter to the desire to reduce stream bank and bed erosion in the Township and reduce the impairments that exist in the Tohickon Creek watershed.

Section 801. Prohibited Discharges and Connections

1. Part C6 and C8 refers to non-contaminated HVAC condensation and hydrostatic test water discharges and notes that these discharges are authorized unless "they are determined by the Township to be significant contributors to pollution of a regulated small MS4 or to the waters of this Commonwealth." I am concerned that the water temperature from these discharges could exceed temperatures consistent with the water in the natural watercourses. Extremely warm temperature has the potential to negatively impact the fisheries and aquatic biota in the streams and should be considered a pollutant that is prohibited from discharge to natural streams and wetlands.

Recommendations

It is recommended that the Stormwater Management Ordinance for Bedminster Township be revised to include the clarifications and supplemental information referenced in this report. The Lower Delaware Wild and Scenic River Management Plan seeks to maintain existing water quality in the watershed and the Stormwater Management Ordinance has the potential to ensure that the water quality in an already identified impaired watershed does not suffer further degradation.

To ensure that the Lower Delaware River Wild and Scenic status is protected, it is my opinion that the ordinance should be updated to include additional protections against stream erosion and water quality impairments. Clarity should be added to the definitions in the ordinance and the standards that projects must comply with.

I have attached a copy of my resume (Attachment A of this document) outlining my background and qualifications. Should you have any questions or would like to discuss this report further, please do not hesitate to reach out to me directly at 732.735.3440 or by email mary@rippledwatersllc.com.

Sincerely,

Mary L. Paist-Goldman, P.E.
Founder

Attachments
Attachment A – Resume
Attachment B – PA Stormwater Best Management Practices Manual Chapter 6.7.3
Attachment C – Guidance in Determining Bankfull Stream Width in Pennsylvania

Attachment A

Resume

Rippled Waters Engineering, LLC

Mary L. Paist-Goldman, P.E.
Principal, Owner

Education:

- B.S. 2000. Civil Engineering, University of Maryland, College Park, MD

Professional Certifications:

- Professional Engineer:
  Maryland, New Jersey, North Carolina, New York, Pennsylvania
- Rosgen Level I – Applied Fluvial Geomorphology Certification

Professional Affiliations:

- Musconetcong Watershed Association, Board Trustee
- Musconetcong River Management Council Member Alternate
- North Jersey RC&D Technical Advisory Committee member

Areas of Expertise:

- Wetland restoration and mitigation
- Stream restoration and stabilization
- Floodplain management and design
- Stormwater management design
- Teaching – continuing education courses at introductory to advanced levels
- Permitting and regulatory compliance
- Hydrologic and hydraulic modeling
- Dam removals, dam inspections and inundation/breach analyses
- Onsite wastewater disposal system design – including alternative systems
- Wastewater and watershed management planning and design

Summary of Qualifications:

Ms. Paist-Goldman has more than 20 years of experience in the fields of wetland and stream restoration, stormwater management, regulatory compliance, hydrology and hydraulics, dam safety, and wastewater management. Prior to founding Rippled Waters Engineering in 2018, Ms. Paist-Goldman served as Principal Engineer and Director of Engineering Services at Princeton Hydro. Her attention to detail and creative eye lead to out-of-the-box solutions to complex stormwater, stream, wetland, and wastewater problems.

Throughout her career, Ms. Paist-Goldman has designed dozens of projects with low impact development techniques, green infrastructure, and with a focus on water quality – particularly in regard to TMDL compliance. She has designed rain gardens, cistern systems for water re-use in the form of landscape irrigation, bioretention islands, manufactured LID devices, and constructed wetlands. She has developed projects with goals of zero discharge upon completion, groundwater recharge to address aquifer deficits, and retrofits to reduce water quality impacts on Category One waters and EV streams.

Additionally, Ms. Paist-Goldman has served as Project Manager and Lead Designer for a multitude of wetland restoration and mitigation projects. Frequently, these projects are planned for use as mitigation banks or serve as mitigation for development onsite. Working closely with wetland ecologists and landscape architects, she has designed a variety of wetlands including subtidal channels, marsh, and upland habitats for estuarine and marine systems. She also has experience in design development of living shorelines and edge treatments for coastal resiliency and climate change.

Ms. Paist-Goldman has been actively involved in regulatory compliance since the beginning of her career. She is an expert at navigating the New Jersey Department of Environmental Protection’s (NJDEP) Division of Land Use Regulation’s Flood Hazard Area Rules and demonstrating compliance with the Flood Hazard Area Control Act. Ms. Paist-Goldman has extensive experience in dealing with the NJDEP Bureau of Nonpoint Pollution Control and the Dam Safety programs. She served on the Hunterdon County Stormwater Ordinance Review Committee, was an active participant in the preparation of the Hunterdon County model ordinance, and has given presentations to municipalities and colleges and universities throughout the State of New Jersey on the impacts and requirements of the Stormwater Management Rules (N.J.A.C. 7:8). She prepared Stormwater Management Plans for various municipalities and Stormwater Pollution Prevention Plans for various colleges and municipalities.

Ms. Paist-Goldman’s modeling experience includes hydrologic, hydraulic, and pollutant loading modeling for a variety of projects types, from developing floodplain limits, designing culvert openings for new and replacement bridge and culvert crossings, water quality impact analyses, dam inundation analyses, and stormwater facility design and analysis. She is skilled in the use of a wide range of software, including ESRI ArcMap Geographic Information Systems (GIS); United States Army Corps of Engineers' (USACE) HEC-HMS, HEC-RAS; WinSLAMM; XP-SWMM, and HydroCAD.

Ms. Paist-Goldman is experienced in dam breach analyses and dam removal design. She has also prepared inundation mapping, Emergency Action Plans, Operation and Maintenance Manuals and Dam inspection reports for both low and high hazard dams. She has completed dozens of dam safety inspections throughout New Jersey and Pennsylvania and has experience with dam owners to address deficiencies on dams from low to high hazard.

Additionally, Ms. Paist-Goldman has designed wetland mitigation projects ranging in size from less than one acre to nearly 100 acres in size. These projects are planned for use as mitigation banks or serve as mitigation for development onsite. Working closely with wetland scientists, Ms. Paist-Goldman has designed a variety of wetland habitats including creation, enhancement, restoration, and preservation. The designs have included the use of check dams and detailed grading; subtidal channels, wetland pools, intertidal marsh, and upland island habitats for both freshwater and estuarine systems.

Select Project Experience

Stream and Wetland Mitigation Bank, Charles County, MD (2015-2018) – Served as project manager and lead design engineer for design and permitting of approximately 85 acres of wetland and approximately 1,500 feet of stream restoration associated with mitigation impacts for work at a military base in the same watershed. The wetland hydrology incorporated both groundwater and surface water inputs and the design incorporated floodplain reconnection through Protocol 3 of the Chesapeake Bay Expert Panel Report.

Stream Restoration for MS4 Compliance, Prince Georges County, MD (2017-2019) – Served as project manager and lead design engineer for the preliminary design of approximately 6,900 linear feet of stream restoration in accordance with the Chesapeake Bay Expert Panel Report. Restoration activities were designed for first order, second order, and third order tributaries in a holistic approach addressing stream bed and bank erosion together with stream geomorphology using a combination of rock and large woody debris.

Dam Removal and stream restoration, Hunterdon County, NJ (2011-2017) – Project manager for the completion of a feasibility study, final design, and permitting for the removal of a run of the river dam on a river in New Jersey, which was the first blockage from the confluence with the Delaware. Removal of the dam increased the total unobstructed river miles within the Wild and Scenic designation region.

Urban stream restoration and floodplain connectivity project, Trenton, NJ (2008-2011) – Project manager for the completion of engineering design, permitting, and construction management services associated with the restoration of approximately 900 feet of urban stream including daylighting a portion of the stream that had been piped within the City of Trenton.

Publications and Presentations

M. Paist-Goldman. Navigating the Permitting Process to Implement a Mitigation Project in New Jersey. Society for Wetland Scientists Annual Meeting. 30 May 2019, Baltimore, MD.

M. Paist-Goldman and Beth Styler-Barry. 2018. Recognizing the Power of Dam Removal to Reconnect & Restore our Ecosystem. NJ Land Conservation Rally, 2 March 2018, New Brunswick, NJ.

G. Messinger, C. Hall, L. Peterson, P.E. and M. Paist-Goldman, P.E.. 2011. "Walnut Brook Riparian Restoration Project," Land and Water Magazine, January/February 2011.

Attachment B

PA Stormwater Best Management Practices Manual Chapter 6.7.3

BMP 6.7.3: Soil Amendment & Restoration

Soil amendment and restoration is the process of improving disturbed soils and low organic soils by restoring soil porosity and/or adding a soil amendment, such as compost, for the purpose of reestablishing the soil's long-term capacity for infiltration and pollution removal.

Key Design Elements

- Existing soil conditions should be evaluated before forming a restoration strategy.
- Physical loosening of the soil, often called subsoiling, or tilling, can treat compaction.
- The combination of subsoiling and soil amendment is often the more effective strategy.
- Compost amendments increase water retention.

Potential Applications

Residential:	Yes
Commercial:	Yes
Ultra Urban:	Yes
Industrial:	Yes
Retrofit:	Yes
Highway/Road:	Yes

Stormwater Functions

Volume Reduction:	Low/Med.
Recharge:	Low/Med.
Peak Rate Control:	Medium
Water Quality:	Medium

Water Quality Functions

TSS:	85%
TP:	85%
NO3:	50%

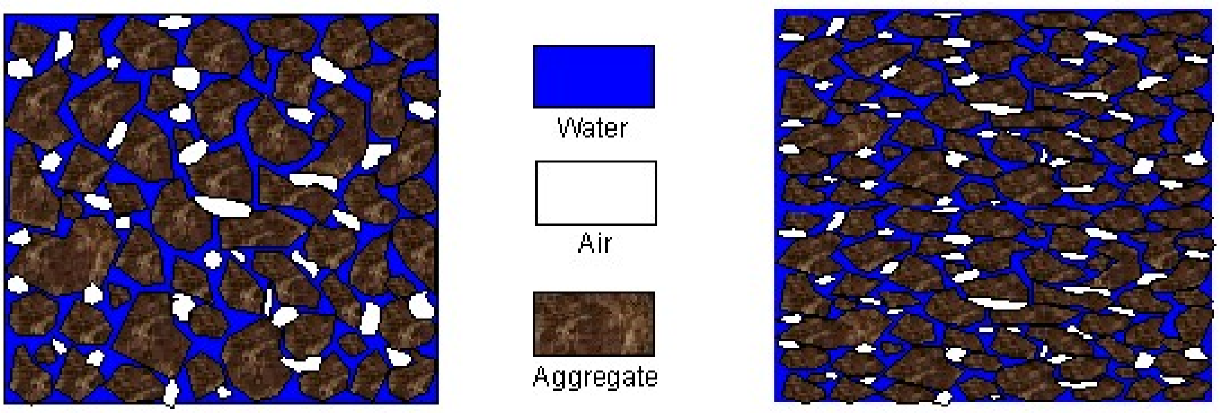
Problem Description

Animals, farm equipment, trucks, construction equipment, cars, and people cause compaction. Wet soil compacts easier than dry soil. Natural compaction occurs due to special chemical or physical properties, and these occurrences are called "hard pans". A typical soil after compaction has strength of about 6,000 kPa, while studies have shown that root growth is not possible beyond 3,000 kPa.

Different Types of Compaction

1) Minor Compaction – surface compaction within 8-12" due to contact pressure, axle load > 10 tons can compact through root zone, up to 1' deep

2) Major Compaction – deep compaction, contact pressure and total load, axle load > 20 tons can compact up to 2' deep (usually large areas compacted to increase strength for paving and foundation with overlap to "lawn" areas)



good physical condition **poor physical condition (compacted)**

In general, compaction problems occur when airspace drops to 10-15% of total soil volume. Compaction affects the infiltrating and water quality capacity of soils. When soils are compacted, the soil particles are pressed together, reducing the pore space necessary to move air and water throughout the soil. This decrease in porosity causes an increase in bulk density (weight of solids per unit volume of soil). The greater the bulk density, the lower the infiltration and therefore the larger volume of runoff.

Different types of soils have bulk density levels at which compaction starts to limit root growth. When root growth is limited, the uptake of water and nutrients by vegetation is reduced.

Soil organisms are also affected by compaction; biological activity is greatly reduced, decreasing their ability to intake and release nutrients.

The best soil restoration is the complete revegetation of woodlands, as "A mature forest can absorb as much as 14 times more water than an equivalent area of grass." (DNREC and Brandywine Conservancy, 1997) (See Structural BMP 6.7.2 Landscape Restoration and use in combination with this BMP)

Soil Restoration Methodology

Soil restoration is a technique that can be used to restore and enhance compacted soils or soils low in organic content by physical treatment and/or mixture with additives such as compost. Soil restoration has been shown to alter soil properties known to affect water relations of soils, including water holding capacity, porosity, bulk density and structure. Two methods have been shown to restore some of the characteristics of soils that are damaged by compaction; tilling and addition of amendments such as compost or other materials.

One of the options for soil amendment is compost, which has many benefits. It improves the soil structure, creating and enhancing passageways in the soil for air and water that have been lost due to compaction. This recreates a better environment for plant growth. Compost also supplies a slow release of nutrients to plants, specifically nitrogen, phosphorous, potassium, and sulfur. Using compost reuses natural resources, reducing waste and cost.

Soil amendment with compost has been shown to increase nutrients in the soil, such as phosphorus and nitrogen, which provides plants with needed nutrients, reducing or eliminating the need for fertilization. This increase in nutrients results in an aesthetic benefit as turf grass and other plantings establish and proliferate more quickly, with less maintenance requirements. Soil amendment with compost increases water holding and retention capacity, improves infiltration, reduces surface runoff, increases soil fertility, and enhances vegetative growth. Compost also increases pollutant-binding properties of the soil properties, which improves the quality of the water passing through the soil mantle and into the groundwater.

The second method is tilling, which involves the digging, scraping, mixing, and ripping of soil with the intent of circulating air into the soil mantle in various layers. Compaction down to 20 inches often requires ripping for soil restoration. Tilling exposes compacted soil devoid of oxygen to air and recreates temporary air space.

Bulk density field tests may be used to determine the compaction level of soils.

Soil Texture	Ideal Bulk densities	Bulk densities that may afffect root growth	Bulk densities that restrict root growth
	g/cm3	g/cm3	g/cm3
Sands, loamy sands	<1.60	1.69	1.8
Sandy loams, loams	<1.40	1.63	1.8
Sandy clay loams, loams, clay loams	<1.40	1.6	1.75
Slilt, silt loams	<1.30	1.6	1.75
Silt loams, silty clay loams	<1.10	1.55	1.65
Sandy clays, silty clays, some clay loams (35-45% clay)	<1.10	1.49	1.58
Clays (>45% clay)	<1.10	1.39	1.47

Source: Protecting Urban Soil Quality, USDA-NRCS

Variations

- Soil amendment media can include compost, sand, and manufactured microbial solutions.
- Seed can be included in the soil amendment to save application time.

Applications

- **New Development (Residential, Commercial, Industrial)** – new lawns can be amended with compost and not heavily compacted before planting, to increase the porosity of the soils.

- **Urban Retrofits** - Tilling of soils that have been compacted before it is converted into meadow, lawn, or a stormwater facility is recommended.

- **Detention Basin Retrofits** – The inside face of detention basins is usually heavily compacted, and tilling the soil mantle on surfaces beyond the constructed embankment will encourage infiltration to take place. Tilling may be necessary to establish better vegetative cover.

- **Landscape Maintenance** – compost can substitute for dwindling supplies of native topsoil in urban areas.

- **Golf Courses** – Using compost as part of the landscaping upkeep on the greens has been shown to alleviate soil compaction, erosion, and turf disease problems.

Design Considerations

1. Treating Compaction by **Soil Restoration**
   a) Soil amendment media usually consists of compost, but can include mulch, manures, sand, and manufactured microbial solutions.
   b) Compost should be added at a rate of 2:1 (soil:compost). If a proprietary product is used, the manufacturer's instructions should be followed in terms of mixing and application rate.
   c) Soil restoration should not be used on slopes greater than 30%. In these areas, deep-rooted vegetation can be used to increase stability.
   d) Soil restoration should not take place within the drip line of a tree to avoid damaging the root system.
   e) On-site soils with an organic content of at least 5 percent can be properly stockpiled (to maintain organic content) and reused.
   f) Procedure: rototill, or rip the subgrade, remove rocks, distribute the compost, spread the nutrients, rototill again.
   g) Add 6 inches compost / amendment and till up to 8 inches for minor compaction.
   h) Add 10 inches compost / amendment and till up to 20 inches for major compaction.

2. Treating Compaction by **Ripping / Subsoiling / Tilling / Scarification**
   a) Subsoiling is only effective when performed on dry soils.
   b) Ripping, subsoiling, or scarification of the subsoil should be performed where subsoil has become compacted by equipment operation, dried out and crusted, or where necessary to obliterate erosion rills.
   c) Ripping (Subsoiling) should be performed using a solid-shank ripper and to a depth of 20 inches, (8 inches for minor compaction).

d) Should be performed before compost is placed and after any excavation is completed.
e) Subsoiling should not be performed within the drip line of any existing trees, over underground utility installations within 30 inches of the surface, where trenching/drainage lines are installed, where compaction is by design.

Subsoiling should not be performed with common tillage tools such as a disk or chisel plow because they are too shallow and can compact the soil just beneath the tillage depth.

3. Other methodologies:
   a) Irrigation Management – low rates of water should be applied, as over-irrigation wastes water and may lead to environmental pollution from lawn chemicals, nutrients, and sediment.
   b) Limited mowing – higher grass corresponds to greater evapotranspiration.
   c) Compost can be amended with bulking agents, such as aged crumb rubber from used tires or weed chips. This can be a cost-effective alternative that reuses waste materials.
   d) In areas where compaction is less severe (not as a result of heavy construction equipment), planting with deep-rooted perennials can treat compaction, however restoration takes several years.

Table 2. Mean runoff from unvegetated test plots during a 30 minute high-intensity (~ 4 in/hr) rain storm

	Biosolids	Yard Trimmings	Bio-industrial	Compacted Subsoil	Topsoil
Geometric mean runoff (mm) during 30-minute rainfall	0.13[a]	<0.01[a]	0.08[a]	26.22[b]	15.54[b]

Values with different letters are significantly different statistically ($p<0.05$) from one another.

Table 3. Mean time to initiate runoff from unvegetated test plots

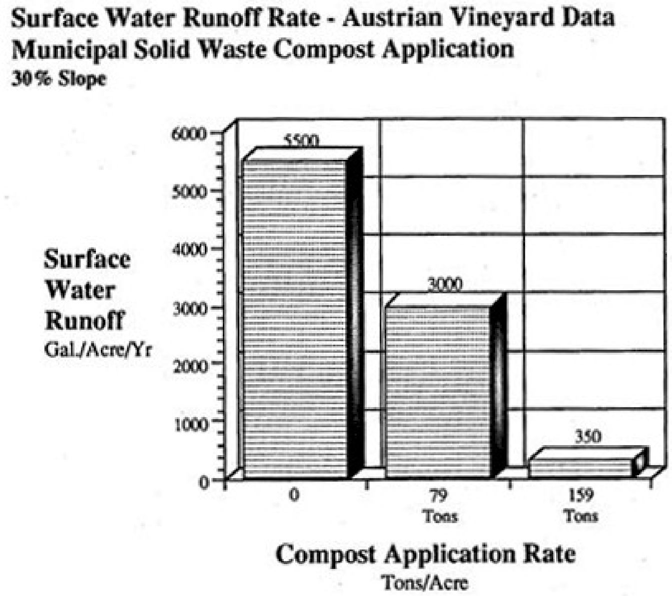
	Biosolids	Yard Trimmings	Bio-industrial	Compacted Subsoil	Topsoil
Mean time (min)	31.08[c]	56.92[d]	32.17[c,d]	4.67[a]	7.83[b]

Values with different letters are significantly different statistically ($p<0.05$) from one another.

Detailed Stormwater Functions

Infiltration Area (If needed)
The infiltration area will be the entire area restored, depending on the existing soil conditions, and the restoration effectiveness.

Volume Reduction Calculations
Soil Amendments can reduce the need for irrigation by retaining water and slowly releasing moisture, which encourages deeper rooting. Infiltration is increased; therefore the volume of runoff is decreased.



Compost amended soils can significantly reduce the volume of stormwater runoff. For soils that have either been compost amended according to the recommendations of their BMP, or subject to restoration such that the field measured bulk densities meet the Ideal Bulk Densities of Table 1, the following volume reduction may be applied:

Amended Area (ft^2) x 0.50in x 1/12 = Volume (cf)

Peak Rate Mitigation
See Section 8 for peak rate mitigation.

Water Quality Improvement
See Section 8 for water quality improvement.

Table 4. Adsorbed Mass of Nutrients and Metals in Unvegetated Plot Runoff From 30-Minute, High-Intensity (100-mm/hr.) Rainstorm

	Compost Treatments			Conventional Treatments	
	Biosolids	Yardwaste	Bioindustrial Compost	Compacted Subsoil	Topsoil
Element	Geometric Mean (mg)				
Chromium	0.01[b]	<0.01[a]	<0.01[b]	0.92[c]	0.76[c]
Copper	0.02[b]	<0.01[a]	0.01[b]	1.03[c]	0.66[c]
Nickel	<0.01[b]	<0.01[a]	<0.01[b]	0.96[c]	0.67[c]
Lead	0.01[b]	<0.01[a]	<0.01[b]	1.82[c]	0.95[c]
Zinc	0.10[b]	<0.01[a]	0.03[b]	6.55[c]	3.99[c]
Nitrogen	0.47[b]	<0.01[a]	0.09[a,b]	266.65[c]	211.87[c]
Phosphorus	0.45[b]	<0.01[a]	0.09[a,b]	36.47[c]	29.07[c]
Potassium	0.17[b]	<0.01[a]	0.09[a,b]	103.94[c]	71.57[c]

Means within the same row with different letter designations are significantly different ($p<0.05$).

Highest | Medium | Lowest

Construction Sequence

1. All construction should be completed and stabilized before beginning soil restoration.

Maintenance Issues

The soil restoration process may need to be repeated over time, due to compaction by use and/or settling. (For example, playfields or park areas will be compacted by foot traffic.)

Cost Issues

Tilling costs, including scarifying sub-soils, range from $800/ac to $1000/ac.

Compost amending of soil ranges in cost from $860/ac to $1000/ac.

Specifications

The following specifications are provided for information purposes only. These specifications include information on acceptable materials for typical applications, but are by no means exclusive or limiting. The designer is responsible for developing detailed specifications for individual design projects in accordance with the project conditions.

1. SCOPE

    a. This specification covers the use of compost for soil amendment and the mechanical restoration of compacted, eroded and non-vegetated soils. Soil amendment and restoration is necessary where existing soil has been deemed unhealthy in order to restore soil structure and function, increase infiltration potential and support healthy vegetative communities.

    b. Soil amendment prevents and controls erosion by enhancing the soil surface to prevent the initial detachment and transport of soil particles.

2. COMPOST MATERIALS

    a. Compost products specified for use in this application are described in Table 1. The product's parameters will vary based on whether vegetation will be established on the treated slope.

    b. Only compost products that meet all applicable state and federal regulations pertaining to its production and distribution may be used in this application. Approved compost products must meet related state and federal chemical contaminant (e.g., heavy metals, pesticides, etc.) and pathogen limit standards pertaining to the feedstocks (source materials) in which it is derived.

    c. Very coarse compost should be avoided for soil amendment as it will make planting and crop establishment more difficult.

d. **Note 1** - Specifying the use of compost products that are certified by the U.S. Composting Council's Seal of Testing (STA) Program (www.compostingcouncil.org) will allow for the acquisition of products that are analyzed on a routine basis, using the specified test methods. STA participants are also required to provide a standard product label to all customers, allowing easy comparison to other products.

3. SUB-SOILING TO RELIEVE COMPACTION

a. Before the time the compost is placed and preferably when excavation is completed, the subsoil shall be in a loose, friable condition to a depth of 20 inches below final topsoil grade and there shall be no erosion rills or washouts in the subsoil surface exceeding 3 inches in depth.

b. To achieve this condition, subsoiling, ripping, or scarification of the subsoil will be required as directed by the owners s representative, wherever the subsoil has been compacted by equipment operation or has become dried out and crusted, and where necessary to obliterate erosion rills. Sub-soiling shall be required to reduce soil compaction in all areas where plant establishment is planned. Sub-soiling shall be performed by the prime or excavating contractor and shall occur before compost placement.

c. Subsoiled areas shall be loosened to less than 1400 kPa (200 psi) to a depth of 20 inches below final topsoil grade. When directed by the owner's representative, the Contractor shall verify that the sub-soiling work conforms to the specified depth.

d. Sub-soiling shall form a two-directional grid. Channels shall be created by a commercially available, multi-shanked, parallelogram implement (solid-shank ripper). The equipment shall be capable of exerting a penetration force necessary for the site. No disc cultivators chisel plows, or spring-loaded equipment will be allowed. The grid channels shall be spaced a minimum of 12 inches to a maximum of 36 inches apart, depending on equipment, site conditions, and the soil management plan. The channel depth shall be a minimum of 20 inches or as specified in the soil management plan. If soils are saturated, the Contractor shall delay operations until the soil will not hold a ball when squeezed. Only one pass shall be performed on erodible slopes greater than 1 vertical to 3 horizontal. When only one pass is used, work should be at right angles to the direction of surface drainage, whenever practical.

e. Exceptions to sub-soiling include areas within the drip line of any existing trees, over utility installations within 30 inches of the surface, where trenching/drainage lines are installed, where compaction is by design (abutments, footings, or in slopes), and on inaccessible slopes, as approved by the owner's representative. In cases where exceptions occur, the Contractor shall observe a minimum setback of 20 feet or as directed by the owner's representative. Archeological clearances may be required in some instances.

4. COMPOST SOIL AMENDMENT QUALITY

a. The final, resulting compost soil amendment must meet all of the mandatory criteria in Table 4.

5. COMPOST SOIL AMENDMENT INSTALLATION

   a. Spread 2-3 inches of approved compost on existing soil. Till added soil into existing soil with a rotary tiller that is set to a depth of 6 inches. Add an additional 4 inches of approved compost to bring the area up to grade.

   b. After permanent planting/seeding, 2-3 inches of compost blanket will be applied to all areas not protected by grass or other plants

References

"The Compaction of Urban Soils", Technical Note #107 from Watershed Protection Techniques, Article 36, 3(2): 661-665.

Dallas, H. and A. Lewandowski, 2003. Protecting Urban Soil Quality: Examples for Landscape Codes and Specifications. USDA Natural Resources Conservation Services.

OCSCD, 2001. *Impact of Soil Disturbance During Construction on Bulk Density and Infiltration in Ocean County, New Jersey*. Ocean County Soil Conservation District, Schnabel Engineering Assoicates, Inc., USDA Natural Resources Conservation Services. www.ocscd.org.

Pitt, R. et al., 2002. "Compacted Urban Soils Effects on Infiltration and Bioretention Stormwater Control Designs."

Pitt, R. et al., 2002. "Infiltration Through Disturbed Urban Soils and compost-Amended Soil Effects on Runoff Quality and Quantity."

"The Relationship Between Soil and Water", Soils for Salmon, The Urban Environment, 1999

"Soil Quality Resource Concerns: Compaction", USDA Natural Resources Conservation Service, 1996

"Soil Quality Resource Concerns: Available Water Capacity", USDA Natural Resources Conservation Service, 1998

"Specifications for Soil Amendments", Low Impact Development Center, Inc., www.lid-stormwater.net/soilamend/soilamend_specs.htm

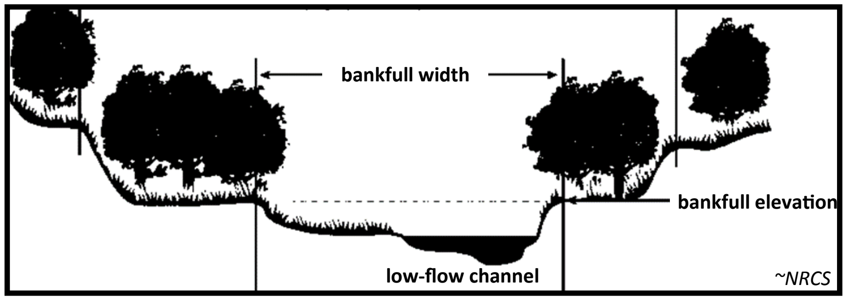
"Urban Soil Compaction", Soil Quality – Urban Technical Note, No. 2, USDA Natural Resources Conservation Services, 2000.

Department of Natural Resources and Environmental Control Division of Soil and Water. *Delaware Erosion and Sediment Control Handbook for Development*. Newark, DE

Attachment C

Guidance in Determining Bankfull Stream Width in Pennsylvania

Guidance in Determining Bankfull Stream Width in Pennsylvania



<u>Bankfull Flow</u>: This flow stage is determined by the elevation point of incipient flooding, indicated by deposits of sand or silt at the active scour mark, break in stream bank slope, perennial vegetation limit, rock discoloration, and root hair exposure. It is typically called the "channel-forming flow", with roughly a 1.5-2 year recurrence interval, and is where a stream will typically begin to access its floodplain.

<u>Bankfull Width</u> – The width of the channel at the bankfull elevation.

<u>Finding a "Reference Reach" of a Stream</u>:
Because streams vary widely in composition, slope, and manmade impacts, it is impossible to create a set of "instructions" for determining bankfull that will work on every channel. The goal when determining bankfull flow is to find a "Reference Reach" of the stream that is the most representative of the natural channel. This sometimes means moving further upstream or down, or skipping sections of stream that are unnaturally widened or constricted. **<u>Be flexible</u> in choosing your bankfull measurement locations in order to find a section of stream that is the most representative of the natural channel.**

<u>Procedure for Determining Bankfull Width Near a Road / Stream Crossing Structure:</u>

Location: Start at a location away from the influence of any culvert or bridge, since they often impact width. To do this, <u>roughly</u> estimate bankfull channel width, then go at least 5 times that distance away from the structure. Looking upstream is preferred, but downstream reaches can be used if necessary *(see locations to avoid below).*

Determine Bankfull: Using the indicators below, find the elevation that matches the most bankfull criteria, using both sides of the channel. Start on the side with the best indicators. Begin at the stream and move up the bank to a point you are sure is above bankfull. Then start moving back down the bank looking for indicators to determine where the bankfull elevation is. Try to match that elevation with indicators on the opposite bank. Stretch a measuring tape across the stream at your bankfull mark(s), noting that the tape should be level, to measure the bankfull channel width. Continue moving upstream or downstream, taking successive measurements that are at least 1/2 bankfull width apart (for example, if the first bankfull measurement it 16 feet, move at least 8 feet away before taking another measurement). Attempt to get at least 5 measurements, and average them together.

<u>Field Indicators of Bankfull Flow</u>: *(listed in order from most to lease reliable indicators)*

Change in Bank Slope: Bankfull flows are often associated with "benches" or the top of the stream bank, unless the stream is entrenched or has been altered in the past.

Depositional Features: The top of features such as point bars and mid-channel bars are often indicators of the bankfull flow elevation. Use these elevations to look for additional clues on each bank at the same elevation.

Changes in Particle Size: Streams drop sediment when they start accessing their floodplain. A Change in particle size along a stream bank (from gravelly, to silty or sandy) often indicates bankfull elevation.

Vegetation Changes: Although not as reliable, changes in vegetation can indicate bankfull elevation.

Scour Features: Erosion and scour lines can be used if other features cannot be located.

<u>Locations to Avoid in Determining Bankfull Flow</u>: *(if possible)*

Logjams: These structures tend to increase the bankfull width temporarily in their immediate vicinity.

Manmade Impacts: Avoid locations with wall, weirs, dams, rip-rap, pipes. etc.

Bedrock Outcroppings: Bedrock can hide indicators of bankfull flow and alter channel width.

Braided Channels: Measure upstream or downstream of any braided channels if at all possible.

Tributaries/Springs: Measure bankfull between road crossing and any incoming flows that may increase width.

Hard Meander bends: Hard bends make it difficult to find good indicators since the stream is moving laterally.

<u>Additional Bankfull Determination Tips</u>:

- Bankfull flows will be level across the channel, so make sure your tape is level when measuring bankfull widths.
- When looking for bankfull indicators, think logically about a 1.5-2 year recurrence interval. Does it make sense that the points you are measuring as bankfull will see flow with that frequency?
- On entrenched streams, or streams with historically high sediment impacts (legacy sediments), bankfull elevation is often below the elevation of the "top of stream bank" due to many years of man-made impacts.
- Note that tree roots and other vegetation can exist below the bankfull elevation, especially in dry years.
- Measuring bankfull is often easier during Spring and Fall when vegetation is dormant.
- **<u>Be flexible</u> in your measurement locations to find the best "Reference Reach" of a natural channel.**